Testimony to the House of Representatives'
Energy Subcommittee of the Science Committee
Dr. Andrew C. Klein
Professor and Head, Department of Nuclear Engineering and Radiation Health Physics
Director, Radiation Center, Oregon State University

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Chairman Biggert, Mr. Larson and members of the Subcommittee, I want to thank you for this opportunity to discuss a very important aspect of the energy future of our country. My name is Andrew Klein and I am Professor and Head of the Department of Nuclear Engineering and Radiation Health Physics and the Director of the Radiation Center at Oregon State University. I also chair the Department of Energy's Nuclear Energy Research Advisory Committee's Subcommittee on Nuclear Laboratory Requirements.

According to the Department's charge to our subcommittee a "key Department of Energy objective is to make Idaho National Laboratory the leading nuclear energy research laboratory in the world in ten years from its inception." Furthermore, our subcommittee has been charged with identifying the "characteristics, capabilities, and attributes a world-class nuclear laboratory would possess". In addition, the Department expects the "members of this subcommittee to become familiar with the practices, culture, and facilities of other world-class laboratories – not necessarily confined to the nuclear field – and use this knowledge to recommend what needs to be implemented at Idaho." Finally, the Department has asked us to report our conclusions and recommendations by the end of fiscal year 2004. I expect it will be a very busy summer for our subcommittee.

We have assembled an experienced and dedicated group of nuclear science and engineering professionals for this subcommittee including members with backgrounds in the nuclear power industry, national laboratories and academia. The members of the subcommittee are Dr. Beverly Hartline, who has held leadership roles with the Argonne and Jefferson National Laboratories; Dr. Robert Long, who joins us today, was a faculty member and Department Chair at the University of New Mexico prior to joining GPU Nuclear, from where he has retired; Dr. Robert Schock, who has extensive experience at the Lawrence Livermore National Laboratory; and Dr. Michael Sellman, who is the President and Chief Executive Officer of Nuclear Management Corporation. We look forward to providing our input to the Department of Energy on what it will take to enable the Idaho National Laboratory to be considered as a "World-Class Nuclear Energy Research and Development Laboratory". However, since our subcommittee has a long way to go before we finish our report, I want to stress that my comments here today are strictly my own, and not necessarily the views of the subcommittee or the full NERAC.

Our subcommittee is conducting a literature review to learn what others consider to be the characteristics, attributes, and qualities of world-class research and development laboratories. It was clear early in our studies that this was not the first time that this question has been asked and we expect to learn quite a bit from the work of others.

We plan to visit world-class laboratories, including both nuclear energy related and non-nuclear laboratories, in the United States, Canada, Europe, Japan and South Korea to collect data, gather information, talk with laboratory leadership, and tour a variety of world-class facilities. Some of the visits that we will make during our investigation include laboratories of the Department of Defense, Department of Commerce, and other Federally Funded Research and Development Centers, in addition to many of the national laboratories within the Department of Energy complex.

We are also conducting a survey of science and engineering leaders, again both from within the nuclear community and beyond, to learn what they consider to be the key characteristics, capabilities and attributes of a world-class nuclear energy research and development organization. One of the items we found early in our literature review was a report from the National Research Council that established the following definition for a world-class research and development laboratory [1]:

> "A world-class R&D organization is one that is recognized by peers and competitors as among the best in the field on an international scale, at least in several key attributes."

In our visits and in our survey, we are asking numerous nuclear and non-nuclear energy leaders whether they agree with this definition, and if not, how would they change or improve it. We are also asking them what makes their laboratory world-class.

Again, speaking personally and not for the entire subcommittee, I feel that there are three necessary components to a world-class national laboratory, supported by a fourth essential element. The first three are: recruiting and retaining world-class people; building and maintaining world-class facilities; and providing world-class research and development programs to utilize the first two. The final building block of any world-class laboratory is a resolute and sustained commitment to see the task completed.

The first, and most important component of building a world-class national laboratory is attracting and keeping the very best people. The INL will need to attract the best and brightest scientists and engineers from many different technical disciplines in order to be successful. It will require not just the best nuclear scientists and engineers, but will include material scientists, chemical engineers, physicists, chemists, computational specialists and a range of other specialists who will build the base for a world-class laboratory. Attracting and retaining high caliber researchers will be challenging, especially in the early years, and it is critical that the INL take a flexible approach to get these people involved in the work of the new laboratory. The INL may need to include a wide variety of appointment types and opportunities ranging from full-time employment to part-time appointments or other collaborative appointments to consulting arrangements to be able to include the right people in this enterprise. The INL will also need to be a leader in utilizing new and expanding electronic technologies to draw people in from other geographic areas for open collaborations to enable the best ideas to be brought to the problems that INL will be tackling.

Drawing the very best people to come to work with the INL will require the second component, establishing a series of highly respected and unique user facilities. One aim here is to get researchers from universities, industry and other national laboratories to want to work with the people and facilities already sited at the INL. It is clear that the best people are attracted to working closely with other top people in outstanding facilities and locations. University faculty who are involved on research projects with the INL will bring their ideas, and more importantly their best graduate students to work with other outstanding people to make good use of the facilities and infrastructure that will be developed at INL. Some of those students will be attracted to stay after their graduation, become INL researchers themselves, and further build the INL to world-class status. The subcommittee has not been tasked with suggesting specific facilities requirements, but if you get the top people in the various disciplines related to nuclear energy development together, in very short time they will arrive at a fairly comprehensive list of needed facility improvements and the new and diverse capabilities they need.

The third component of a world-class nuclear research and development laboratory is the specific research programs that will fund the research of these top people and utilize these high quality facilities. A wide diversity of well-funded research programs will be essential to building this laboratory, and to enable the further utilization of nuclear energy for electricity and hydrogen production in this country and around the world. The diversity of programs will also be helpful going forward as budgets fluctuate with different administration priorities and other political changes in the future.

A good example of all of these components coming together to form a sustained world-class laboratory is the Jet Propulsion Laboratory, in Pasadena, CA. As you know, JPL's main line of research is the development and operation of space probes for NASA, but if you look deep inside of JPL you will see that it has all of these three elements – fantastic people, superb facilities and exciting and compelling programs and missions. It also has, on site, all of the disciplinary capabilities across the wide spectrum of research and development that they need, but they also utilize scientists and engineers from across the US to accomplish their missions. INL needs to have all of these elements to succeed in its mission.

Underneath all of this, and providing the motivation and purpose for the laboratory is a resolute and sustained commitment from the U.S. Government. This persistent support must not just be from the Office of Nuclear Energy, but needs to be encouraged by the entire Department and as much of the rest of the Government as possible. I also feel that Congress should take ownership of this new laboratory to enable it to succeed. I am very glad to participate in this discussion today, as it shows the Congress's intention to see that the INL gets started off in the right direction. The Government's commitment to date has provided the initiative to establish the Idaho National Laboratory from the two existing entities in Idaho Falls, and must provide the sustained leadership and financial support required for the INL to meet its mission

My personal observation, however, is that the budgets proposed for the development of this new national capability are totally inadequate. Also, the proposed plan to shift funding from the clean-up operation to the new nuclear energy R&D mission over a period of ten years, as the clean-up mission is completed seems overly optimistic. The new capabilities we are trying to establish at INL need much greater focus and commitment than this. The next few years are especially critical. What happens during the first five years of the INL will strongly determine the path that it takes to world-class status. It must be done the right way, the first time.

<u>Answers to questions from the Subcommittee</u>

First, you have asked me to comment on the role that Argonne National Laboratory and the other national laboratories with nuclear expertise should play in nuclear energy R&D after the INL is established. It is my belief that all of these capabilities, and to the list of national laboratories I would add the nation's universities and industry with nuclear energy related programs, will be needed going forward if we are to fully develop the nuclear energy systems that will be required to reduce our nation's dependence on fossil fuels for electricity production and transportation fuels. The national laboratories, universities and industry all will need to play important roles in the development of the technology related to this energy source and in the production of the people needed to design and operate these facilities safely and efficiently.

The Idaho National Laboratory is being established within a number of important communities, and I would like to speak here about some of these now. The support and encouragement from all of these communities will be essential to the INL's success.

The first community I would like to mention is the community of researchers and scholars who are, and will be, involved in nuclear energy related research – the primary mission of the INL. That community is an international one and the INL must develop close interactions with many, if not most of these researchers in order to get the best input and ideas in order to apply them to the problems involved in developing the systems and components needed. Since it will be impossible to lure all of these individuals to come together permanently in Idaho Falls, the INL must find creative and innovative ways to attract and retain the most important individuals and research groups to work closely with them. These individuals and groups currently reside in the national laboratories, industry, and universities, and some of them are students in our nation's K-12 school systems. Interactions with other national laboratories, industry and universities should be constant since many of the world's best nuclear energy researchers are already located at other locations. Finding creative ways to involve all of these people in the development and deployment of new nuclear energy systems will be among the important success criteria for the laboratory.

A second community is the local community in Idaho Falls and the neighboring areas. While the compelling nature of the activities being conducted by the INL will bring excitement to the lives of those working directly on the projects at the laboratory, the cultural and recreational opportunities of the local area will sustain these individuals and their families over the long run of the laboratory. It will be important for those involved to build this aspect of this second community.

A third community that will also be valuable to cultivate will be a broad set of local industrial capabilities in Idaho and the region – high tech spin offs and imports, new and old companies, will be needed to complement the activities and capabilities to be assembled within the INL. It will be important for the INL to work closely with the State of Idaho and the City of Idaho Falls to develop the broad set of local industries which will enable the INL to attract people with the appropriate nuclear and other technical skills and their families.

The broad involvement of all of these communities will be essential to the development of the INL over its first ten years. They will be important to the development of the diversity of the knowledge base, the diversity of the talent base, and the diversity of the workforce at the INL.

Second, you have asked my opinion about specific programs that the Department should support at the INL if it is to be considered a multi-purpose laboratory. First, let me say that I believe that the INL should not be restricted to the very focused mission of developing a nuclear reactor for electricity production or the production of hydrogen by utilizing the high temperature heat output from a reactor. The INL needs a much broader mandate than this to be considered to be successful in reaching the goal of being considered world-class. Thus, I believe that the INL should be a multi-purpose laboratory and that it will be very important for the Department to support a broad set of research activities at the INL.

It is going to take more than just nuclear engineers to make the INL a world-class laboratory. As you can expect from someone who has all of his degrees in nuclear engineering and teaches in a university nuclear engineering and health physics program, I think very highly of the skills and capabilities of nuclear engineers. However, they will not be enough. Skilled scientists and engineers of all types, including computational scientists, mechanical engineers, materials scientists, chemical engineers, physicists, electrical engineers, etc. will be needed to supply the INL with the capabilities it needs to achieve its mission of reaching world-class status in 10 years.

Some of the other capabilities that I feel would be important to have at INL include computational facilities and software development, high performance materials development, applied physical sciences, including chemistry and physics, research on manufacturing modular and large system components, transportation systems for large system components and radioactive waste, and national security technology research and development related to nuclear science and technology, to name a few. All of these added capabilities are complementary to the nuclear energy and environmental cleanup technologies that are the natural programs for the INL.

World-class computational facilities will be an important draw for some of the people needed at INL. Several years ago the INEEL was one of the leaders in developing computer codes for reactor design and simulation. With the advances in computing in recent years much more is now possible – it is even conceivable that every molecule of gas flowing through a reactor core could be modeled. Leadership class computers could open up huge new areas of research in reactor design leading to entirely new approaches and conceptual designs.

High performance software development aimed at a basic principles approach to modeling could allow engineers and scientists to eliminate the use of correlations and other corrective measures in their simulations. This involves a much greater understanding of the physical and theoretical treatment of neutron interaction physics, fluid flow, heat transfer, materials interactions in these systems at the microscopic and molecular level.

Experimental capabilities are needed to verify, validate, and compare computer calculations to actual physical measurements on a variety of scales - even full-scale systems. The work in my Department at Oregon State University over more than a decade, and our close interactions with the Department of Energy, the Nuclear Regulatory Commission, INEEL, Westinghouse and others on scaled system simulation and testing of a variety of advanced nuclear reactors is a very good example of the importance of being able to compare calculations with physical measurements to ensure the accuracy of the computer codes that are used for system design, safety evaluation and licensing.

Finally, with respect to your questions about the Next Generation Nuclear Plant, or NGNP, I feel that the development and demonstration of a high temperature reactor's capabilities to efficiently produce electricity for our businesses and homes and hydrogen for our transportation needs is important to the progress of INL to world-class status. However, development of world leadership in nuclear energy development by INL should be considered to be independent of the construction and operation of the NGNP. The people, facilities, and programs at INL will be very useful to the development and operation of the NGNP. However, NGNP development should be considered a result of creating a world-class laboratory at INL, and not the reverse. Many additional multidisciplinary research facilities and capabilities will be required at INL to meet this objective. There are undoubtedly ways to design the NGNP to be a versatile, multidisciplinary research tool, rather than simply a demonstration project. This will require the involvement of the best people at the INL and across the nation's nuclear energy R&D universities, national laboratories and industry.

Thank you, once again for this opportunity to talk with you about establishing the Idaho National Laboratory as a world-class nuclear energy research and development laboratory. I look forward to further discussions with you today, and in the future.

Reference

[1] National Research Council, "World-Class Research and Development," National Academy Press, Washington, DC, 1996.

Brief Biography for Andrew C. Klein
June 2004

Andrew C. Klein became the Head of the Department of Nuclear Engineering at Oregon State University (OSU) in July 1996. In 2002 the Department's name was changed to the Department of Nuclear Engineering and Radiation Health Physics to reflect the broad nature of the activities in the Department. In October 2002 he also became the Director of the OSU Radiation Center with line responsibility for the University's 1.1 megawatt research reactor and the other facilities managed by the Center.

Dr. Klein received his B.S. in Nuclear Engineering from Pennsylvania State University in 1977. He went on to complete his M.S. in Nuclear Engineering and his Ph.D., also in Nuclear Engineering from the University of Wisconsin, Madison in 1979 and 1983 respectively.

He has been on the faculty at OSU since September 1985 after serving as a Visiting Assistant Professor of Nuclear Engineering at the University of Cincinnati from August 1983 through August 1985. He was an Assistant Professor of Nuclear Engineering at OSU from September 1985 to July 1990 when he was promoted to Associate Professor. In July 1996 he was promoted to the rank of Professor.

His research interests are wide and varied including space reactor systems design and thermal management, transient analysis of nuclear power systems, microdosimetry, radiation shielding, the technical aspects of arms control nonproliferation, and health physics. He has also conducted research in fusion energy systems design, zircalloy corrosion and radioactive waste management. He has been an author on more than technical 75 publications in these areas.

Dr. Klein is registered as a Professional Engineer (Nuclear) in the State of Oregon. He is an active member of the American Nuclear Society, the Health Physics Society, and the American Society for Engineering Education. From August 1993 through October 2002 Dr. Klein was the Director of the Oregon Space Grant Program, a statewide consortium of universities, colleges, and other educational organizations established in 1990 by the National Aeronautics and Space Administration (NASA). He served one term on the Board of Directors of the American Nuclear Society from June 2000 to June 2003, and has served on the Advisory Committee for *Nuclear Technology* since 1997 and as an Advisory Editor for the *Annals of Nuclear Energy* since 1996. He also served on the Board of Directors of the National Space Grant Alliance, Inc. from January 2001 through October 2002. In January 2001 Dr. Klein was appointed by the U.S. Secretary of Energy to the Department of Energy's Nuclear Energy Research Advisory Committee (NERAC). Dr. Klein was also a member of USDOE's Generation IV Nuclear Energy Systems Roadmap Development team and served as the Technical Director for the Energy Products Crosscut Group in 2001 and 2002. He is a member of NASA's Space Science Advisory Committee and a member of the ABET, Inc. Engineering Accreditation Commission.